QUAERO Manual

Bruce Knuteson*
MIT
(Dated: September 15, 2006)

QUAERO is an interface to the world's frontier energy collider data. Physicists can provide specific hypotheses to QUAERO, in the form of new terms in an effective Lagrangian describing Nature at the electroweak scale. QUAERO can test such hypotheses, quantifying the extent to whch the data (dis)favor the hypothesis relative to the Standard Model. This document is intended as a brief user's guide to this interface.

Contents

I. INTRODUCTION

It is generally recognized that the standard model, a successful description of the fundamental particles and their interactions, must be incomplete. Models that extend the standard model often predict rich phenomenology at the scale of a few hundred GeV, an energy regime accessible to the LEP collider. Due in part to the complexity of the apparatus required to test models at such large energies, experimental responses to these ideas have not kept pace. Any technique that reduces the time required to test a particular candidate theory would allow more such theories to be tested, reducing the possibility that the data contain overlooked evidence for new physics.

*Electronic address: knuteson@mit.edu; URL: http://mit.fnal.gov/~knuteson/

Once data are collected and the backgrounds have been understood, the testing of any specific model in principle follows a well-defined procedure. In practice, this process has been far from automatic. Even when the basic selection criteria and background estimates are taken from a previous analysis, the reinterpretation of the data in the context of a new model often requires a substantial length of time.

Ideally, the data should be "published" in such a way that others in the community can easily use those data to test a variety of models. The publishing of experimental distributions in journals allows this to occur at some level, but an effective publishing of a multidimensional data set has not yet been accomplished by a large particle physics experiment. The problem appears to be that such data are very context-specific, requiring detailed knowledge of the complexities of the apparatus. This knowledge must somehow be incorporated either into the data or into whatever tool the non-expert would use to analyze those data. QUAERO (Latin for "I search for, I seek") is designed for this purpose. QUAERO has recently been extended to allow the non-expert to analyze data collected by collaborations at LEP, HERA, and the Tevatron.

II. WEB PAGE

The QUAERO web page has the following entries.

A. Articles

Links to this manual and to articles describing the underlying analysis algorithms are provided at the top of the form.

B. Signal

The new physics hypothesis is specified by providing commands to either PYTHIA, SUSPECT, or MADEVENT.

1. Pythia

If generation of the signal within PYTHIA is desired, the radio button in front of `pythia` should be selected. PYTHIA is used to model initial and final state radiation and quark fragmentation, in addition to generating parton-level events. Pythia v6.221 is used within QUAERO.

Usual PYTHIA commands (as fortran statements) are recognized, and are passed to PYTHIA using `pygive`. In addition, the cross section can be varied by including "`xsec =` σ" in the PYTHIA input box, where σ is a number in units of picobarns, or by including the command "`kfactor =` k", which multiplies the cross section by the k-factor k.

2. Suspect

If generation of Supersymmetry within PYTHIA is desired, using SUSPECT to produce the particle spectrum, the radio button in front of `suspect` should be selected. SUSPECT is used to determine the SUSY particle spectrum, and this spectrum is passed to PYTHIA for the generation of events.

3. MadEvent

If generation of the signal within MADEVENT is desired, the radio button in front of `MadEvent` should be selected. MADEVENT is used to perform an exact tree-level calculation, with the resulting parton-level events passed through PYTHIA to model initial and final state radiation and quark fragmentation. The format of the input file is specified in Appendix A.

C. Email

The results of the query will be returned by email to the address provided here.

D. Model

The email returned to you will include the string you provide in this box. This may be useful when automatically processing the results of a set of QUAERO submissions.

E. Target Time

QUAERO has several things in common with a computer chess program. In particular, the thoroughness of the analysis QUAERO is able to perform increases with allotted time. In the box next to the clock on the QUAERO web page a target run time can be provided, in units of whole kiloseconds. QUAERO will target the sophistication of its analysis to meet the allotted time. The default (and minimum) runtime is 1 ks. If the same hypothesis is submitted with different target run time, the "official" QUAERO result for that hypothesis is the result returned when allowed the longer run time.

F. Submit.

Clicking this button submits the request.

G. Password.

QUAERO simultaneously serves up both open and password-protected analyses. The box to the right of the **submit** button will accept a password string. QUAERO uses data from those experiments whose password is contained as a substring in the string of characters you provide. Data from DØ Run I requires no password. Data from Aleph, L3, and H1 is presently password restricted.

III. RESULTS

QUAERO's result is returned in an email to the address provided. The primary result is encapsulated in a single number: the decimal logarithm of the probability of seeing the data assuming the correctness of the proposed hypothesis divided by the probability of seeing the data assuming the correctness of the Standard Model. Links to plots showing the distributions of the data, the proposed hypothesis, and the standard model in the variables considered are also provided.

IV. SUMMARY

This article has provided an extremely brief introduction to QUAERO, a web-based tool that facilitates analysis of high energy physics collider data. Comments, questions, and suggestions are welcome, and should be sent by email to the author.

APPENDIX A: MADEVENT INPUT

Particles should be specified in lines such as:

```
PARTICLE  Q  Q~  F  S  npm(1)  npm(2)  T  Q  99
```

Mass and width parameters should be specified as `npm(1)` through `npm(99)`.

Interactions should be specified in lines such as:

```
INTERACTION  Q  Q  z  np_coupl_rLR(1) QNP
```

Special couplings can be provided with couplings such as:

```
INTERACTION  Qx Q  z  np_coupl_rLR(1) QNP dmx
```

where `dmx` indicates a dimension 5 dipole moment interaction. Specification of a coupling with `dmx` or another string of three letters determines which HELAS routine is called for the evaluation of the vertex. Details on the specifications of interactions are provided in the HELAS manual or in an informal HELAS appendix documenting the dipole interaction.

QNP should be used for all new couplings. The coupling should be specified as the following for different types of vertices:

```
dmx              np_coupl_cLREM(1)
FFV              np_coupl_rLR(1)
FFS              np_coupl_cLR(1)
VVV              np_coupl_r(1)
VVS,VSS,or SSS   np_coupl_c(1)
```

Here `np_coupl` represents a new particle coupling, the suffix `r` represents a real coupling, the suffix `c` represents a complex coupling, the suffix `LR` indicates the coupling has both left and right components, and the suffix `EM` indicates the coupling has both electric and magnetic dipole components. Allowed indexes are again 1–99 for each of the coupling types.

Parameters should be specified in lines such as:

```
PARAMETER      npm(1) = 260.4
PARAMETER      np_coupl_r(1) = 4.52
PARAMETER      np_coupl_c(1) = (0.5,0.16)
PARAMETER      np_coupl_rLR(L,1) = 0.53
PARAMETER      np_coupl_rLR(R,1) = 0.32
PARAMETER      np_coupl_cLR(L,1) = (0,0.51)
PARAMETER      np_coupl_cLR(R,1) = (0.12,0)
PARAMETER      np_coupl_cLREM(L,EDM,1) = (0,0.49)
PARAMETER      np_coupl_cLREM(R,MDM,1) = (0.14,0)
```

Complex numbers are written in Fortran style as (realPart,imaginaryPart). The left component of `np_coupl_rLR(1)` is specified by `np_coupl_rLR(L,1) = 0.53`. The right component of `np_coupl_cLR(1)` is specified by `np_coupl_cLR(R,1) = (0.12,0)`. The electric dipole piece of the left component of `np_coupl_cLREM(1)` is specified by `np_coupl_cLREM(L,EDM,1) = (0,0.49)`. The magnetic dipole piece of the right component of `np_coupl_cLREM(1)` is specified by `np_coupl_rLREM(R,MDM,1) = (0.14,0)`.

Quaero is unable to evaluate numerical expressions in this input file; parameter values should be given as numbers rather than expressions involving other parameters. In cases where parameter dependences are intricate, a short program should be written to produce the Quaero input file given the underlying parameters, rather than constructing the Quaero input file by hand.